Historic, archived document

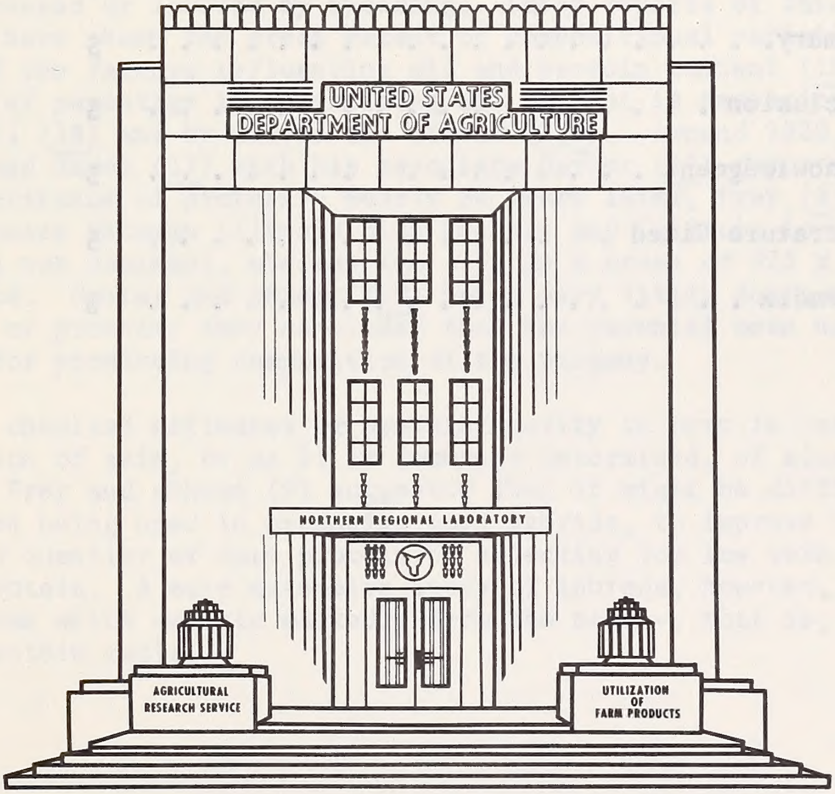
Do not assume content reflects current
scientific knowledge, policies, or practices.

A381
R31AC
Cop. 2

U. S. DEPT. OF AGRICULTURE
NATIONAL AGRI[illegible] LIBRARY
JAN 23 1964
CURRENT SERIAL RECORDS

ARS-71-31
November 1963

OIL AND PROTEIN CONTENT OF CORN INBRED LINES


UNITED STATES
DEPARTMENT OF AGRICULTURE
NORTHERN REGIONAL LABORATORY
AGRICULTURAL RESEARCH SERVICE
UTILIZATION OF FARM PRODUCTS

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

Page

Introduction 1

Materials and Methods. 2

Results and Discussion 2

Summary. 5

Conclusion 5

Acknowledgment 5

Literature Cited 5

Appendix 8

Prepared by

Northern Utilization Research and Development Division
Peoria, Illinois

OIL AND PROTEIN CONTENT OF CORN INBRED LINES

By F. R. Earle,[1] J. J. Curtis,[2] and J. E. Hubbard[3]

INTRODUCTION

Oil is a valuable constituent in corn. Any increase in oil content should result in an increase in the value of corn for feeding and industrial processing. Also for food and feed use, any increase in the amount or quality of protein should give added nutritional value.

The Illinois Selection Experiment, started in 1896 by Hopkins (13-16),[4] gave the first evidence that the oil and protein content of corn can be either increased or lowered by breeding. Later reports of this continuing experiment have shown the great extent of compositional variation attained and some of the factors influencing oil and protein content (19-21). The importance of parentage in determining oil content is emphasized by Sprague and Brimhall (18) and by Curtis and others (2,3). Around 1920, East and Jones (7) and Hayes (11) with his associate Garber (12) reported studies of the inheritance of protein. Nearly 30 years later, Frey (8) found that in crosses between Illinois High Protein and Illinois Low Protein, low protein was dominant, whereas Kuo (17) in a cross of W23 X R53 found no dominance. Genter and others (10) noted very little dominance for either oil or protein; they concluded that the parental mean was the best criterion for predicting composition of the progeny.

One of the chemical estimates of protein quality in corn is based on a determination of zein, or as it is commonly determined, of alcohol-soluble nitrogen. Frey and others (9) suggested that it might be difficult, with inbreds then being used in producing corn hybrids, to improve both the quality and quantity of corn protein by selecting for low zein in relation to total protein. A more extensive study of inbreds, however, might disclose some which deviate markedly from the norm--, that is, toward a low zein:protein ratio.

---

[1] Research chemist, Industrial Crops Laboratory, Northern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Peoria, Ill.

[2] Present address: Toronto, Kans.

[3] Physical scientist, Northern Utilization Research and Development Division, ARS, USDA, Peoria, Ill.

[4] Underscored numbers in parentheses refer to Literature Cited, p. 5.

MATERIALS AND METHODS

A uniform field performance test of 145 inbred lines was conducted in 1948 by members of the North Central Corn Improvement Conference (4); in 1949 the test was repeated (5) with some changes in lines studied. Seed for planting each inbred line was supplied by a single station, preferably the originator, but observations and analyses were done on a state basis. The availability of this series afforded an unusual opportunity to examine the oil and protein content of a large number of inbred lines grown at different locations. Samples of grain representing the 145 inbreds grown in 1948 were supplied, upon request, by the agricultural experiment stations of Iowa, Nebraska, Illinois, and Indiana. Grain samples were not replicated. After samples from 3 stations had been analyzed and the resulting data tabulated, samples of 20 of the 145 inbreds were requested from 8 additional locations.[5] In the 1949 tests, 20 inbreds for oil and protein analyses were requested from the same 12 locations except Wisconsin was substituted for North Dakota. The 20 inbreds, both in 1948 and 1949, were not all grown at all 12 locations.[6] There were nine inbreds common to both years' tests.[7]

Samples were finely ground in a hammer mill. Nitrogen was determined by the Kjeldahl-Wilfarth-Gunning method (1); oil, by the AOAC method for oil in soy flour (1); and alcohol-soluble nitrogen (only 1948 crop samples from Nebraska), by the following method: 80 ml. of 60-percent ethanol were added to 2.8 g. of finely ground corn in a 100-ml. volumetric flask. The mixture was shaken well and allowed to stand overnight at 80° C. It was then diluted to 100 ml. volume, and a 50-ml. portion of the extract was analyzed for nitrogen.

RESULTS AND DISCUSSION

Oil and protein contents of 145 inbreds grown in 1948 at Ames, Iowa; Lafayette, Ind.; Urbana, Ill.; and Lincoln, Nebr., and 4-state averages are given in the Appendix, Table 1. Inbreds varied somewhat in oil and protein contents from one location to another but, in general, each inbred had about the same relative rank at each location. Averages from the 4 stations showed that oil content of the 145 inbreds ranged from 2.8 to 5.8 percent, and protein content from 9.4 to 15.8 percent. In 1949, the inbreds maintained their same general ranks in both oil and protein contents at the several locations. Data on these inbreds are given in the Appendix, Tables 2 and 3.

---

[5] North Dakota, South Dakota, Minnesota, Michigan, Ohio, Missouri, Kentucky, and Kansas.

[6] In 1948 only 1 inbred, and in 1949, 8 inbreds were grown at all 12 locations.

[7] L317, M14, I205, Hy2, Tr, 38-11, Kys, WF9, and K4.

Of the nine inbreds common to both the 1948 and 1949 tests, seven were grown both years at eight identical locations. The statistical analysis of variance for these is presented in the Appendix, Table 4. Neither season nor location had a significant effect when considered alone, but the interaction location × season was significant at the 1-percent level for both oil and protein. Inbred line had, by far, the major effect on both oil and protein content (significant at the 1-percent level). Inbred lines were significantly different from each other and were consistent at each of the locations. The interaction inbred × location was not significant. There is no test available for the inbred × season interaction.

To test further the differences shown between inbreds, lines were ranked in order of increasing mean oil and protein contents, and Duncan's multiple range test (6) was applied:

Inbred[8]	I205	Tr	Hy2	WF9	Kys	38-11	K4
	d	d	cd	c	b	ab	a
Mean oil, %	3.6	3.6	3.8	4.1	4.8	5.1	5.5

Inbred[8]	Hy2	Tr	I205	WF9	K4	Kys	38-11
	c	c	bc	b	b	a	a
Mean protein, %	10.4	10.5	11.4	12.1	12.4	13.7	14.1

The alcohol-soluble nitrogen content of 145 inbreds grown at Lincoln, Nebr., in 1948 was determined and the proportion of nitrogen that was alcohol soluble was calculated (Appendix, Table 1). The alcohol-soluble nitrogen consists principally of zein but includes some other nitrogen compounds. The proportion of nitrogen that is alcohol soluble ranged from 42.2 to 61.0 percent. In general, inbreds with a high protein content tended to have a high proportion of alcohol-soluble nitrogen.

A plot is shown in Figure 1 of the protein content versus proportion of protein that is alcohol soluble for the 145 inbred lines analyzed for alcohol-soluble protein. The regression line was calculated, and the 95-percent limits are shown by the two dotted lines. Results are similar to those previously reported (9). About 37 percent of the variation in alcohol-soluble protein is accounted for by differences in protein content. Although variability of the inbreds analyzed indicates that some selection for protein quality in high-protein inbreds might be possible, it is evident that lines deviating most markedly from the average alcohol-soluble protein:total protein ratio show a high ratio rather than the desired low ratio.

---

[8] Inbred lines with different letter designations are significantly different in mean oil or protein content from other inbred lines at the 5-percent level of significance; those with identical letters are not.

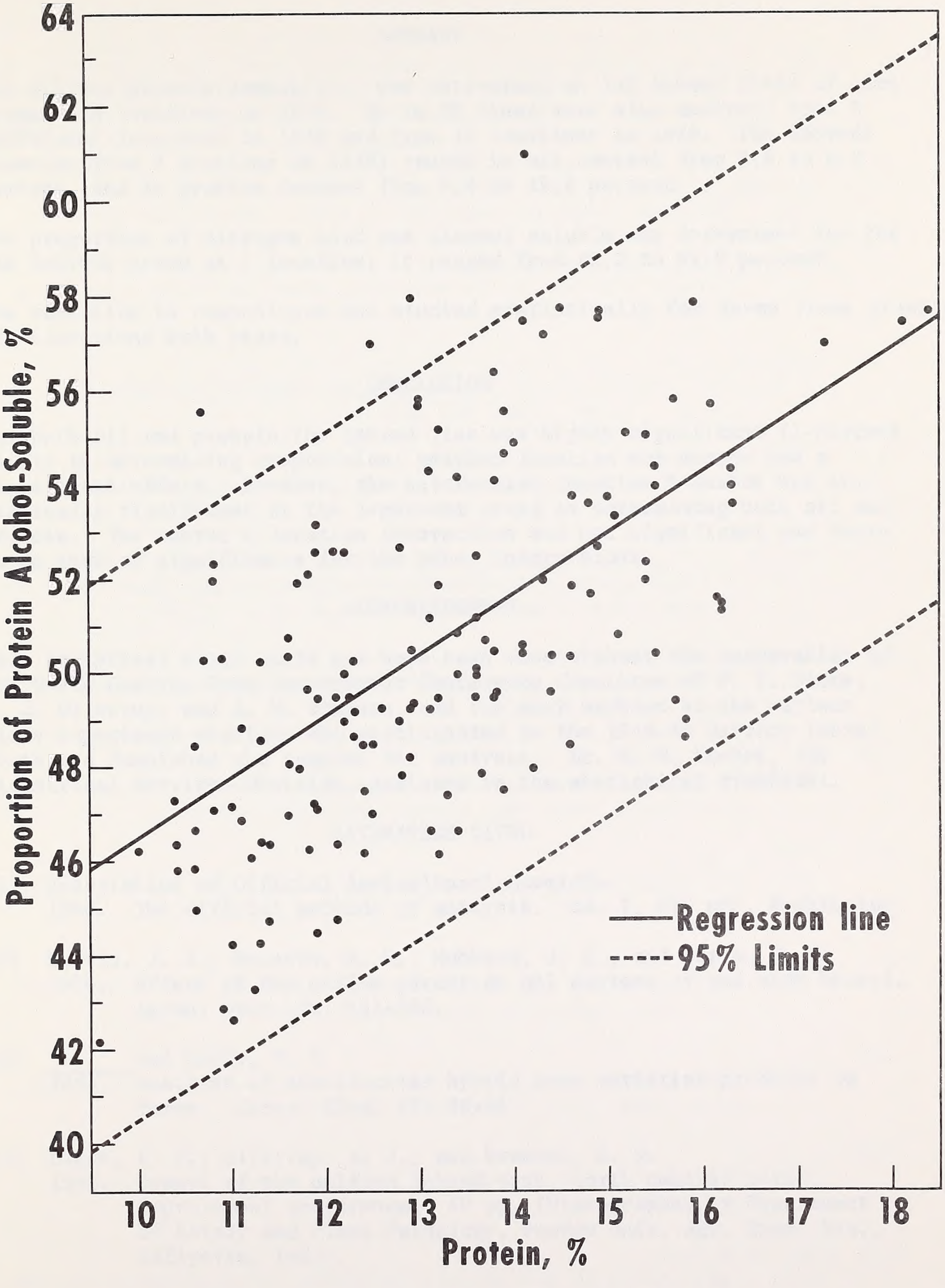


Figure 1.--Regression of proportion of protein that is alcohol-soluble on the percent protein in 145 inbred lines grown at Lincoln, Nebr., in 1948.

SUMMARY

The oil and protein composition was determined on 145 inbred lines of corn grown at 4 locations in 1948. Up to 20 lines were also analyzed from 8 additional locations in 1948 and from 12 locations in 1949. The inbreds (average from 4 stations in 1948) ranged in oil content from 2.8 to 5.8 percent, and in protein content from 9.4 to 15.8 percent.

The proportion of nitrogen that was alcohol soluble was determined for the 145 inbreds grown at 1 location; it ranged from 42.2 to 61.0 percent.

The variation in composition was studied statistically for seven lines grown at eight locations both years.

CONCLUSION

For both oil and protein the inbred line was highly significant (1-percent level) in determining composition; neither location nor season had a significant effect. However, the interaction location × season was statistically significant at the 1-percent level in determining both oil and protein. The inbred × location interaction was not significant and there is no test of significance for the other interactions.

ACKNOWLEDGMENT

This analytical study could not have been done without the cooperation of the North Central Corn Improvement Conference Committee of F. F. Dicke, A. J. Ullstrup, and A. M. Brunson, and the many workers at the various State experiment stations who participated in the 1948-49 Uniform Inbred Tests and furnished the samples for analysis. Dr. W. F. Kwolek, ARS Biometrical Services Division, assisted in the statistical treatment.

LITERATURE CITED

(1) Association of Official Agricultural Chemists.
1950. The official methods of analysis. Ed. 7, 910 pp., Washington.

(2) Curtis, J. J., Brunson, A. M., Hubbard, J. E., and Earle, F. R.
1956. Effect of the pollen parent on oil content of the corn kernel. Agron. Jour. 48: 551-555.

(3) ______ and Earle, F. R.
1946. Analyses of double-cross hybrid corn varieties produced on farms. Cereal Chem. 23: 88-96.

(4) Dicke, F. F., Ullstrup, A. J., and Brunson, A. M.
1948. Report of the uniform inbred test, north central corn improvement conference. 40 pp. (Mimeographed by Department of Botany and Plant Pathology, Purdue Univ. Agr. Expt. Sta., Lafayette, Ind.).

(5) ______Ullstrup, A. J., and Brunson, A. M.
1949. Report of the second uniform inbred test, north central corn improvement conference. 30 pp. (Mimeograph No. 40, Department of Botany and Plant Pathology, Purdue Univ. Agr. Expt. Sta., Lafayette, Ind.).

(6) Duncan, D. B.
1955. Multiple range and multiple F tests. Biometrics 11: 1-42.

(7) East, E. M., and Jones, D. F.
1920. Genetic studies on the protein content of maize. Genetics 5: 543-610.

(8) Frey, K. J.
1949. The inheritance of protein and certain of its components in maize. Agron. Jour. 41: 113-117.

(9) ______Brimhall, B., and Sprague, G. F.
1949. The effects of selection upon protein quality in the corn kernel. Agron. Jour. 41: 399-403.

(10) Genter, C. F., Eheart, J. E., and Linkous, W. N.
1957. Oil and protein relationships between inbred lines and their single cross progeny. Agron. Jour. 49: 283-285.

(11) Hayes, H. K.
1922. Production of high-protein maize by mendelian methods. Genetics 7: 237-257.

(12) ______and Garber, R. J.
1919. Synthetic production of high-protein corn in relation to breeding. Amer. Soc. Agron. Jour. 11: 309-318.

(13) Hopkins, C. G.
1898. The chemistry of the corn kernel. Ill. Agr. Expt. Sta. Bul. 53, pp. 127-180.

(14) ______
1899. Improvement in the chemical composition of the corn kernel. Ill. Agr. Expt. Sta. Bul. 55, pp. 205-240.

(15) ______
1899. Improvement in the chemical composition of the corn kernel. Amer. Chem. Soc. Jour. 21: 1039-1057.

(16) ______
1902. Methods of corn breeding. Ill. Agr. Expt. Sta. Bul. 82, pp. 525-589.

(17) Kuo, Chun-Yen.
1953. Inheritance of and interrelationships of tryptophan, niacin, protein and kernel weight in corn. Mich. State Col. (Doctoral Diss.) University Microfilms, Ann Arbor, Mich., Doctoral Diss. Series Pub. 7162. 66 pp.

(18) Sprague, G. F., and Brimhall, B.
1949. Quantitative inheritance of oil in the corn kernel. Agron. Jour. 41: 30-33.

(19) Woodworth, C. M., and Jugenheimer, R. W.
1949. Breeding and genetics of high protein corn. Amer. Seed Trade Assoc., Hybrid Corn Div., Indus. Res. Rpt. 8: 75-83.

(20) ______ Leng, E. R., and Jugenheimer, R. W.
1952. Fifty generations of selection for protein and oil in corn. Agron. Jour. 44: 60-65.

(21) ______ and Mumm, W. J.
1936. New records set in altering composition of corn kernels. Ill. Agr. Expt. Sta. Ann. Rpt. (1934-35) 48: 47-50.

APPENDIX

TABLE 1.--Oil and protein analyses of inbreds grown in uniform inbred tests at 4 experiment stations in 1948
/Moisture-free basis/

Entry no.	Inbred line	Wt. per 1,000 kernels, av. 3 stations 1/	Oil					Protein (N x 6.25)					Proportion N alcohol soluble (Nebr.)
			Station: Ind.	Ill.	Nebr.	Iowa	Av.	Station: Ind.	Ill.	Nebr.	Iowa	Av.	
		Grams	%	%	%	%	%	%	%	%	%	%	%
1	ND1	211	4.4	4.5	4.8	4.6	4.6	14.1	13.8	13.7	14.0	13.9	50.7
2	ND5	223	4.7	4.4	4.9	4.4	4.6	11.4	11.2	12.1	11.0	11.4	49.5
3	ND36	191	5.2	5.2	5.1	4.8	5.1	12.2	12.1	12.5	12.1	12.2	57.0
4	ND167	146	4.3	3.9	4.4	3.9	4.1	12.6	13.8	15.7	12.9	13.8	49.4
5	ND203	201	4.7	3.8	4.1	4.2	4.2	14.9	14.6	15.5	13.7	14.7	54.4
6	ND211	173	3.6	3.9	3.8	3.8	3.8	13.4	12.6	13.8	12.2	13.0	49.5
7	ND255	162	4.2	4.2	4.6	4.4	4.4	15.1	14.2	16.3	13.4	14.8	54.0
8	ND30	163	5.9	5.7	5.8	5.4	5.7	15.1	15.4	16.3	16.4	15.8	54.4
9	ND230	195	5.3	5.0	5.0	4.8	5.0	11.9	11.7	14.1	11.5	12.3	50.4
10	ND283	184	4.7	4.7	4.9	4.7	4.8	16.2	15.9	16.1	14.8	15.8	55.8
11	A90	187	4.5	4.3	4.0	4.2	4.2	12.2	12.9	16.2	11.8	13.3	51.5
12	A111	119	3.9	4.2	4.2	4.2	4.1	13.0	12.7	15.4	12.8	13.5	52.4
13	SD102	211	3.3	3.6	3.2	3.2	3.3	11.2	11.9	12.6	10.9	11.6	49.3
14	SD104	196	4.4	4.0	4.2	3.9	4.1	12.8	13.2	14.6	13.3	13.5	53.8
15	SD105	183	5.3	4.9	5.0	4.6	5.0	14.1	12.8	15.2	12.4	13.6	55.1
16	SD106	223	4.4	3.9	3.7	4.8	4.2	13.5	13.9	18.1	13.4	14.7	57.4
17	SD107	170	3.9	3.6	3.7	3.5	3.7	11.3	10.7	14.1	10.9	11.8	50.7
18	A21	159	4.4	4.1	4.7	4.3	4.4	14.2	14.6	17.3	14.7	15.2	57.0
19	A34	221	4.6	5.1	4.8	4.9	4.8	11.2	12.0	13.6	12.2	12.2	50.0
20	A148	200	5.4	5.3	5.2	5.4	5.3	13.1	12.8	14.6	12.4	13.2	51.9
21	A344	210	5.2	4.6	4.8	4.4	4.8	12.0	12.2	15.5	11.6	12.8	54.0
22	A116	213	4.8	3.9	4.0	4.2	4.2	11.8	12.3	15.1	11.6	12.7	50.8
23	A165	212	5.0	4.2	4.8	4.9	4.7	12.1	12.8	14.4	10.8	12.5	49.6
24	C11	226	5.0	4.6	4.2	4.8	4.6	11.1	11.1	15.7	11.6	12.4	48.6
25	C11 Imp.	228	5.0	4.3	4.6	4.3	4.6	11.5	12.1	15.1	11.4	12.5	53.3
26	MS206	246	4.1	4.4	4.3	4.6	4.4	13.2	12.6	13.9	12.5	13.0	54.7
27	A15	133	4.5	4.1	4.6	4.4	4.4	10.9	12.8	13.8	12.4	12.5	47.5
28	W9	178	5.0	4.0	4.1	3.9	4.2	12.2	12.3	13.8	11.6	12.5	54.1

29	W25	273	5.7	5.4	4.7	4.8	5.2	14.8	14.3	16.2	13.8	14.8	51.4
30	Ia.153	193	4.6	3.8	4.2	4.3	4.2	13.1	12.9	16.3	12.4	13.7	53.8
31	W16	192	5.1	4.5	4.8	4.4	4.7	12.0	11.3	14.4	12.0	12.4	50.4
32	A96	210	5.5	5.1	4.6	4.8	5.0	12.6	12.8	14.8	11.7	13.0	53.6
33	A158	175	5.9	5.2	5.1	4.6	5.2	11.1	9.7	12.9	10.0	10.9	49.3
34	A7	174	4.9	4.0	4.1	4.2	4.3	13.6	14.1	15.5	13.2	14.1	50.4
35	A171	209	5.2	4.8	4.5	4.9	4.8	11.5	11.4	13.8	14.0	12.7	52.0
36	C14	141	5.4	4.7	4.4	4.8	4.8	15.9	14.1	18.4	10.8	14.8	57.6
37	C14 Imp.	159	5.2	4.6	5.0	4.8	4.9	14.6	13.0	15.9	13.0	14.1	57.9
38	A12	166	4.7	4.3	3.9	4.8	4.4	14.6	13.0	15.8	14.2	14.4	49.0
39	A385	198	5.0	4.6	4.5	4.6	4.7	13.6	12.4	14.9	11.6	13.1	57.6
40	A131	185	4.6	3.9	4.4	4.3	4.3	12.8	12.2	15.4	10.8	12.8	55.1
41	A188	223	4.8	5.2	4.6	5.1	4.9	13.0	12.5	14.6	10.6	12.7	48.5
42	A357	194	4.2	4.1	4.4	4.4	4.3	11.2	10.4	11.6	9.3	10.6	50.8
43	W10	238	4.9	4.6	4.4	4.4	4.6	13.0	12.2	14.9	11.7	13.0	52.7
44	A166	187	4.2	3.9	3.8	3.4	3.8	11.9	10.5	13.6	10.5	11.6	52.5
45	B8	213	5.2	4.4	4.0	5.0	4.6	11.1	9.4	11.9	12.6	11.2	49.5
46	A340	218	5.2	4.7	4.8	4.4	4.8	13.9	11.9	13.6	9.5	12.2	49.5
47	A334	213	4.9	5.0	4.8	4.8	4.9	15.2	10.9	13.8	10.1	12.5	50.5
48	A374	231	4.9	4.9	4.4	4.8	4.8	14.2	11.2	13.4	11.2	12.5	50.9
49	A375	186	5.2	4.3	4.4	3.9	4.4	14.8	11.9	13.0	11.0	12.7	55.8
50	A322	238	4.7	4.2	4.3	3.9	4.3	11.6	9.6	11.9	9.7	10.7	53.2
51	WR3	206	5.9	5.1	5.6	4.8	5.4	12.0	9.4	10.9	11.1	10.8	50.3
52	A392	154	4.8	4.2	4.5	4.4	4.5	11.9	11.1	11.9	10.9	11.4	52.6
53	A347	193	4.6	3.9	4.4	5.0	4.5	12.5	11.4	14.5	9.6	12.0	57.8
54	Oh51	207	5.1	4.6	4.8	4.1	4.6	10.8	9.0	10.8	11.2	10.4	52.0
55	Oh51A	257	5.0	5.3	5.3	5.1	5.2	12.1	9.4	11.2	10.0	10.7	43.3
56	Oh26	267	5.3	5.0	5.4	5.4	5.3	13.9	12.2	12.3	12.4	12.7	48.7
57	Ill.4226	189	5.1	4.5	4.9	5.0	4.9	14.3	10.2	12.1	10.8	11.8	46.4
58	M14	230	5.8	5.1	5.1	5.4	5.4	12.0	11.6	12.8	10.8	11.8	49.0
59	A71	257	5.1	5.5	4.9	5.6	5.3	12.5	11.3	11.8	11.7	11.8	52.1
60	A311	199	4.8	4.8	4.2	4.7	4.6	11.9	11.0	13.1	11.0	11.8	51.2
61	A395	191	4.4	5.0	4.6	4.6	4.6	12.1	10.2	11.1	9.8	10.8	46.9
62	A73	208	4.8	4.9	5.0	4.9	4.9	10.8	9.3	10.6	9.8	10.1	48.5
63	W23	150	5.3	4.7	4.6	4.8	4.8	10.6	8.8	10.6	9.0	9.8	45.0
64	W26	222	4.7	4.5	5.0	4.8	4.8	15.8	11.8	13.6	12.8	13.5	47.9
65	A25	178	4.5	4.2	4.2	4.1	4.2	12.3	10.2	11.6	9.8	11.0	48.1
66	WF9	224	4.9	4.3	4.2	4.2	4.4	12.8	10.5	11.4	10.6	11.3	46.4
67	W8	216	5.1	4.9	5.3	5.2	5.1	11.1	8.8	10.4	8.6	9.7	45.8
68	W22	227	4.4	4.5	4.5	4.5	4.5	12.0	10.9	12.3	10.9	11.5	49.2
69	Os420	245	4.4	3.2	4.1	4.1	4.0	12.6	11.2	11.0	10.7	11.4	42.6
70	Os426	256	3.9	4.0	3.6	4.0	3.9	13.1	11.6	12.2	11.5	12.1	49.5
71	I205	260	3.5	3.6	3.7	3.8	3.6	12.2	10.1	11.3	9.8	10.8	48.6

TABLE 1.--Oil and protein analyses of inbreds grown in uniform inbred tests at 4 experiment stations in 1948--Continued
/Moisture-free basis/

Entry no.	Inbred line	Wt. per 1,000 kernels, av. 3 stations 1/	Oil					Protein (N x 6.25)					Proportion N alcohol soluble (Nebr.)
			Station					Station					
			Ind.	Ill.	Nebr.	Iowa	Av.	Ind.	Ill.	Nebr.	Iowa	Av.	
		Grams	%	%	%	%	%	%	%	%	%	%	%
72	L289	177	3.9	3.3	3.4	4.4	3.8	12.6	12.8	10.9	10.8	11.8	42.9
73	R2	224	3.7	3.6	3.6	4.1	3.8	11.9	11.1	12.1	10.6	11.4	52.6
74	H5	193	3.8	3.6	3.9	4.2	3.9	13.9	12.9	13.2	11.4	12.8	51.9
75	Oh28	206	3.8	3.8	3.5	4.0	3.8	10.2	9.6	11.3	9.5	10.2	46.4
76	Oh33	212	3.7	3.8	3.5	4.2	3.8	12.1	11.1	12.3	8.4	11.0	50.3
77	B164	217	4.4	4.2	4.2	4.0	4.2	9.9	10.3	10.4	10.6	10.3	46.4
78	Tr	237	3.7	3.6	3.3	3.4	3.5	11.6	9.8	9.6	7.9	9.7	42.2
79	66	251	3.8	3.8	3.5	3.6	3.7	10.9	9.5	10.6	7.6	9.6	46.7
80	Oh40B	258	5.4	4.9	5.2	5.0	5.1	11.4	11.0	12.4	13.2	12.0	47.5
81	Oh65	244	4.8	5.2	4.8	5.2	5.0	14.1	13.4	15.4	9.2	13.0	52.0
82	Oh84	249	5.8	5.6	5.8	5.6	5.7	12.1	11.9	12.2	10.4	11.6	49.0
83	N6	208	5.5	5.1	5.2	4.7	5.1	11.9	11.9	12.5	9.8	11.5	48.5
84	A	159	4.8	4.7	4.7	4.6	4.7	12.4	12.6	13.8	12.9	12.9	49.5
85	L	287	4.8	5.0	4.4	4.9	4.8	11.8	10.8	11.9	8.4	10.7	47.4
86	R4	164	3.9	4.5	3.7	4.4	4.1	12.8	12.6	13.6	10.6	12.4	50.2
87	Hy	219	3.9	3.9	3.1	3.8	3.7	10.9	10.1	11.9	8.8	10.4	47.1
88	Hy2	229	3.9	3.7	3.2	3.4	3.6	9.2	9.7	11.4	9.2	9.9	44.8
89	R59	247	3.8	4.1	3.1	3.6	3.6	10.9	10.8	13.3	9.4	11.1	47.4
90	R61	223	4.2	4.5	4.0	4.5	4.3	11.4	10.5	12.4	10.2	11.1	46.2
91	I234	325	4.4	4.3	3.7	4.1	4.1	9.9	9.6	10.0	8.3	9.4	46.2
92	P8	213	4.8	4.9	4.1	4.4	4.6	10.6	11.7	14.0	9.2	11.4	54.9
93	I224	266	4.2	3.8	3.3	3.6	3.7	11.1	10.8	15.7	9.4	11.8	55.8
94	W17	201	5.6	5.8	4.9	4.5	5.2	11.6	10.2	13.1	9.0	11.0	46.7
95	W20	247	4.2	5.0	4.5	4.6	4.6	12.0	11.9	12.4	10.8	11.8	48.5
96	Oh02	188	2.8	3.0	2.3	2.9	2.8	11.3	10.8	14.2	10.0	11.6	48.0
97	Oh07	263	5.2	5.1	4.7	5.1	5.0	11.4	10.2	11.3	10.0	10.7	50.3
98	90	180	4.8	4.3	3.5	4.1	4.2	12.6	12.0	15.0	11.5	12.8	53.8
99	L317	197	4.6	5.1	4.2	4.7	4.6	12.0	11.9	13.2	10.6	11.9	49.5
100	R30	259	5.5	5.7	5.5	5.5	5.6	11.9	10.8	10.7	11.5	11.2	50.3
101	5120B	333	5.2	5.2	4.5	4.6	4.9	11.1	11.0	11.2	11.4	11.2	46.1

102	K155	252	5.5	5.6	5.1	5.2	5.4	10.2	10.5	11.9	11.8	11.1	44.5
103	Mo.G	214	5.0	4.8	4.8	5.0	4.9	10.9	10.4	11.4	10.0	10.7	44.3
104	B2	236	5.0	4.4	3.6	4.8	4.4	14.2	11.4	13.2	13.3	13.0	46.2
105	Mo.L3	205	4.7	5.2	3.9	4.8	4.7	12.4	11.1	12.5	11.2	12.5	47.0
106	Mo.2RF	261	4.4	3.9	3.7	4.1	4.0	11.6	10.2	10.4	10.5	10.7	47.3
107	Ky27	225	4.5	4.4	3.9	4.4	4.3	9.9	9.9	11.8	10.1	10.4	46.3
108	4-8	216	5.4	5.3	3.9	5.4	5.0	13.9	13.6	16.2	13.0	14.2	51.5
109	540	185	5.4	5.1	4.1	5.0	4.9	12.0	12.1	12.9	10.8	12.0	48.3
110	I159	294	5.0	5.3	4.7	4.5	4.9	11.7	11.2	11.1	11.2	11.3	48.9
111	33-16	248	4.4	4.3	3.8	4.0	4.1	12.5	11.2	11.0	10.2	11.2	47.2
112	K44	252	4.9	5.1	4.6	4.7	4.8	9.2	9.0	11.0	9.7	9.7	44.3
113	K41	185	5.3	4.8	4.6	5.2	5.0	12.1	11.9	13.4	12.2	12.4	50.0
114	K55	247	5.4	5.1	4.8	5.1	5.1	13.2	13.9	12.9	13.0	13.2	50.5
115	K63	257	4.8	5.3	5.1	4.8	5.0	14.4	12.9	14.6	12.9	13.7	50.4
116	Ind.Pr-1	216	4.6	4.7	3.8	4.3	4.4	11.3	10.4	12.1	10.5	11.1	44.8
117	Ky122	221	4.7	4.8	4.0	4.8	4.6	13.1	12.8	13.8	12.5	13.0	56.4
118	Ky49	312	4.0	4.4	3.5	4.3	4.0	12.3	11.1	13.4	11.7	12.0	46.7
119	Ky39	288	4.3	4.6	3.5	3.8	4.0	10.9	10.6	10.8	10.3	10.6	47.1
120	Ky21	295	4.5	4.3	3.9	4.2	4.2	11.2	11.6	12.2	11.8	11.7	50.0
121	Ky58	193	4.9	4.9	4.4	4.8	4.8	11.9	12.2	14.8	12.4	12.8	51.7
122	T18	268	5.8	5.8	5.9	5.8	5.8	13.1	13.3	12.8	13.2	13.1	52.7
123	187-2	235	5.0	5.3	4.5	5.0	5.0	11.8	11.1	10.7	11.5	11.3	55.6
124	38-11	244	5.3	5.7	5.4	5.4	5.5	13.6	12.0	13.4	12.6	12.9	54.2
125	K148	229	4.5	4.8	4.0	4.0	4.3	11.4	12.9	13.3	12.0	12.4	47.9
126	K150	264	4.3	4.4	3.7	4.2	4.2	10.4	10.4	11.6	10.4	10.7	50.3
127	K6	283	3.9	3.7	3.4	3.7	3.7	13.0	11.8	13.0	12.0	12.4	55.8
128	Kys	214	4.8	5.4	4.6	4.8	4.9	13.8	12.8	13.2	14.2	13.5	55.2
129	K201	370	5.4	5.7	5.3	5.1	5.4	12.7	12.2	12.9	13.3	12.8	49.3
130	CI7	258	3.9	4.4	3.7	4.1	4.0	13.8	11.9	11.7	11.9	12.3	51.9
131	K4	195	5.7	6.0	5.6	5.2	5.6	12.6	11.6	12.2	12.4	12.2	52.6
132	H21	245	3.9	4.0	3.5	4.0	3.8	11.6	11.1	11.6	10.2	11.1	47.0
133	H22	299	4.9	5.0	4.6	4.9	4.8	11.6	10.5	10.6	12.0	11.2	45.9
134	H23	312	4.4	4.5	3.8	4.4	4.3	13.5	13.6	12.9	13.4	13.4	58.0
135	K64	287	4.6	4.3	3.8	4.3	4.2	11.2	11.5	10.8	11.0	11.1	52.3
136	CI61	318	3.9	4.0	3.7	4.3	4.0	13.1	13.1	14.3	13.2	13.4	57.2
137	CI2	237	5.1	4.7	4.6	4.3	4.7	15.6	15.4	14.9	15.8	15.4	57.7
138	CI3	202	3.9	4.2	4.0	3.6	3.9	13.4	12.4	11.8	11.2	12.2	49.7
139	CI3a	257	4.4	4.3	4.1	3.8	4.2	12.9	11.2	11.2	12.2	11.9	48.0
140	CI5	307	4.8	5.3	4.9	4.9	5.0	13.8	13.4	13.6	13.5	13.6	51.2
141	CI11b	230	4.2	4.6	3.8	3.9	4.1	11.9	12.2	13.1	11.6	12.2	49.3
142	CI41	323	4.4	4.7	4.1	4.2	4.4	14.1	13.8	13.9	13.4	13.8	55.6
143	CI43	276	3.7	4.2	3.3	3.8	3.8	12.8	12.7	13.1	12.2	12.7	54.3
144	CI23	290	5.5	4.6	4.3	4.9	4.8	14.1	13.8	14.1	14.2	14.0	57.5
145	Mo22	213	5.0	4.7	4.3	4.4	4.6	12.3	12.6	14.2	13.6	13.2	61.0

1/ Indiana, Illinois, Nebraska.

TABLE 2.--Oil content of inbreds grown in uniform inbred test in 1948 and 1949 at 12 stations
/Moisture-free basis/

Inbred	Experiment station												Av.
	N.Dak.	S.Dak.	Minn.	Mich.	Iowa	Nebr.	Ind.	Ohio	Ill.	Mo.	Ky.	Kans.	
	%	%	%	%	%	%	%	%	%	%	%	%	%
							1948						
ND30	5.8	6.0	5.4	6.4	5.4	5.8	5.9	5.8	5.6	---	---	---	5.8
SD106	3.9	3.8	3.4	3.4	4.8	3.7	4.4	3.8	3.9	---	---	---	3.9
A21	4.4	4.2	4.2	4.6	4.3	4.7	4.4	4.2	4.1	---	---	---	4.3
A7	4.4	4.7	4.4	4.3	4.2	4.1	4.9	3.5	4.0	---	---	---	4.3
M14	5.4	4.8	5.2	4.8	5.4	5.1	5.8	5.5	5.0	---	---	---	5.2
W23	5.0	4.5	5.0	4.5	4.8	4.6	5.3	5.0	4.7	---	---	---	4.8
WF9	4.4	4.4	4.4	4.4	4.2	4.2	4.9	4.4	4.2	4.4	4.2	4.6	4.4
I205	---	3.0	3.2	2.6	3.8	3.7	3.5	3.6	3.6	3.4	3.6	4.0	3.5
Tr	---	3.7	3.4	3.4	3.4	3.3	3.7	3.8	3.5	3.2	3.8	3.9	3.6
Hy	---	3.8	4.1	3.2	3.8	3.1	3.9	3.1	3.8	3.8	4.0	4.3	3.7
Hy2	---	3.9	4.1	2.8	3.4	3.2	3.9	3.0	3.8	3.4	3.9	4.4	3.6
Oh02	---	2.6	3.2	2.9	2.9	2.3	2.8	3.0	3.0	2.8	3.0	2.8	2.8
L317	---	4.8	3.9	4.2	4.7	4.2	4.6	3.6	5.0	4.6	4.9	4.3	4.4
K55	---	---	---	---	5.1	4.8	5.4	4.1	5.0	5.4	4.9	5.2	5.0
K63	---	---	---	---	4.8	5.1	4.8	4.4	5.2	5.2	5.0	5.0	4.9
T18	---	---	---	---	5.8	5.9	5.8	5.8	5.8	5.7	5.6	5.8	5.8
38-11	---	---	---	---	5.4	5.4	5.3	5.0	5.6	5.0	5.4	5.4	5.3
Kys	---	---	---	---	4.8	4.6	4.8	4.1	5.5	4.6	4.6	4.9	4.7
K4	---	---	---	---	5.2	5.6	5.7	4.8	5.9	5.7	5.4	5.6	5.5
H23	---	---	---	---	4.4	3.8	4.4	3.0	4.4	4.0	4.1	4.2	4.0
	Wis.						1949						
A25	4.2	4.4	4.3	4.0	4.0	4.1	4.4	4.3	---	---	---	---	4.2
A71	5.0	4.8	5.0	---	4.7	4.8	5.1	5.2	---	---	---	---	4.9
W22	4.4	4.0	4.1	4.1	4.1	4.1	4.6	4.0	---	---	---	---	4.2
L317	3.9	3.8	3.8	4.4	3.9	3.7	3.9	4.2	3.8	4.5	4.3	---	4.0
Os420	3.8	3.5	3.7	3.6	3.9	3.4	3.8	3.9	3.9	3.8	4.1	---	3.8
Oh07	4.5	4.3	4.3	4.5	4.5	4.4	4.3	5.1	4.4	4.5	4.8	---	4.5
WF9	3.8	3.3	4.1	3.8	3.9	3.2	3.8	4.0	3.8	3.6	4.2	4.0	3.8
M14	5.2	4.9	5.2	5.0	5.1	4.9	5.1	5.1	5.0	4.9	5.0	4.7	5.0
I205	3.2	3.6	3.3	3.1	3.2	3.3	3.1	3.3	3.3	3.4	4.0	4.1	3.4

L304A	4.5	4.0	4.6	4.3	4.6	4.1	4.6	4.8	4.7	4.1	4.8	4.8	4.5
A	4.9	4.4	4.7	4.6	4.6	4.2	4.4	4.6	4.4	4.3	4.3	4.5	4.5
Hy2	4.2	3.6	4.1	4.3	3.7	3.6	3.9	4.0	4.1	4.0	4.1	3.8	4.0
Tr	3.7	3.5	3.3	3.7	3.7	3.4	3.8	3.6	3.4	3.6	3.4	3.4	3.5
Oh51A	4.7	5.1	4.8	4.9	5.2	4.7	4.9	4.9	4.9	4.5	4.9	4.9	4.9
38-11	4.9	4.5	5.1	---	4.6	4.9	4.9	4.9	4.7	5.3	4.8	4.6	4.8
C103	4.4	4.2	4.3	---	4.3	4.6	4.3	4.5	3.9	4.6	4.4	3.9	4.3
Kys	---	---	---	---	4.7	4.4	5.0	5.3	4.8	5.1	4.5	4.3	4.8
K4	---	---	---	---	4.9	6.0	5.3	5.6	5.0	6.0	6.1	5.4	5.5
Ky36-11	---	---	---	---	4.1	3.7	4.3	5.2	4.0	4.3	5.0	5.3	4.5
CI7	---	---	---	---	3.7	4.4	3.8	3.7	3.7	3.8	3.9	---	3.9

TABLE 3.--Protein (N x 6.25) content of inbreds grown in uniform inbred test in 1948 and 1949 at 12 stations
/Moisture-free basis/

Inbred	Experiment station												Av.
	N.Dak.	S.Dak.	Minn.	Mich.	Iowa	Nebr.	Ind.	Ohio	Ill.	Mo.	Ky.	Kans.	
	%	%	%	%	%	%	%	%	%	%	%	%	%
							1948						
ND30	16.2	15.4	16.6	16.2	16.4	16.3	15.1	16.0	15.4	---	---	---	16.0
SD106	13.5	13.0	15.4	13.6	13.4	18.1	13.5	15.6	13.9	---	---	---	14.4
A21	15.8	15.6	15.6	14.9	14.7	17.3	14.2	15.6	14.6	---	---	---	15.4
A7	13.8	13.4	13.8	15.1	13.2	15.5	13.6	14.2	14.1	---	---	---	14.1
M14	12.6	12.4	13.6	14.3	10.8	12.8	12.0	12.8	11.6	---	---	---	12.5
W23	10.8	10.8	10.8	11.6	9.0	10.6	10.6	10.4	8.8	---	---	---	10.4
WF9	14.6	14.2	12.4	14.6	10.6	11.4	12.8	12.7	10.5	12.8	11.3	13.4	12.6
I205	---	13.4	12.8	13.0	9.8	11.3	12.2	13.2	10.1	12.0	11.7	10.7	11.8
Tr	---	12.8	13.0	13.8	7.9	9.6	11.6	11.4	9.8	8.6	11.2	11.4	11.0
Hy	---	11.2	11.8	12.2	8.8	11.9	10.9	11.4	10.1	10.7	10.5	11.1	11.0
Hy2	---	11.2	11.1	12.0	9.2	11.4	9.2	11.0	9.7	10.6	10.7	10.3	10.6
Oh02	---	10.8	12.2	11.8	10.0	14.2	11.3	12.8	10.8	11.0	11.2	10.8	11.5
L317	---	13.1	13.9	13.8	10.6	13.2	12.0	12.7	11.9	11.6	12.0	13.0	12.5
K55	---	---	---	---	13.0	12.9	13.2	14.2	13.9	13.6	13.1	12.2	13.3
K63	---	---	---	---	12.9	14.6	14.4	15.8	12.9	13.6	15.1	13.8	14.1
T18	---	---	---	---	13.2	12.8	13.1	12.9	13.3	12.8	13.6	12.4	13.0
38-11	---	---	---	---	12.6	13.4	13.6	13.6	12.0	14.8	14.1	12.4	13.3
Kys	---	---	---	---	14.2	13.2	13.8	14.3	12.8	13.0	14.3	14.1	13.7
K4	---	---	---	---	12.4	12.2	12.6	12.4	11.8	11.4	11.5	10.8	11.9
H23	---	---	---	---	13.4	12.9	13.5	14.0	13.6	13.6	13.9	12.4	13.4
	Wis.						1949						
A25	12.6	13.6	12.4	10.7	13.0	12.6	12.1	10.9	---	---	---	---	12.2
A71	12.1	12.4	12.0	---	11.9	11.9	12.2	11.6	---	---	---	---	12.0
W22	11.4	14.2	12.1	11.3	12.2	12.6	11.8	11.9	---	---	---	---	12.2
L317	13.6	14.2	13.6	12.4	14.7	15.8	12.7	13.8	13.4	12.8	13.1	---	13.6
Os420	11.3	14.4	12.0	10.8	12.1	12.6	11.4	12.6	12.7	12.8	13.8	---	12.4
Oh07	11.8	12.8	10.7	10.9	11.7	11.3	10.6	10.9	11.0	11.3	11.6	---	11.3
WF9	11.5	14.8	11.9	11.4	12.3	13.4	11.4	11.1	11.6	12.4	12.4	13.2	12.3
M14	12.3	15.2	12.7	11.2	11.7	12.4	11.6	12.1	11.8	12.2	12.3	12.5	12.3
I205	12.0	13.7	12.1	11.6	11.2	12.4	11.6	10.7	11.4	10.8	11.9	11.8	11.8
L304A	11.4	12.4	10.3	11.9	12.1	11.3	10.3	10.8	11.1	11.6	11.3	11.8	11.4

A	13.1	15.8	14.7	12.2	14.1	13.8	12.8	13.7	13.0	13.2	12.9	13.7	13.6
Hy2	10.6	13.0	11.5	9.3	11.3	10.4	10.0	10.5	10.4	10.2	9.9	11.6	10.7
Tr	11.4	14.2	10.9	9.9	11.0	11.4	9.7	10.4	9.9	9.9	12.8	11.3	11.1
Oh51A	10.6	13.3	11.2	10.4	10.7	12.4	10.6	11.3	11.2	11.1	11.2	11.9	11.3
38-11	14.4	16.9	16.1	---	15.6	15.1	14.2	12.5	14.7	14.9	15.6	16.2	15.1
C103	11.9	13.8	12.4	---	11.8	12.0	9.8	12.1	11.1	12.4	12.0	12.3	12.0
Kys	---	---	---	---	14.4	14.6	13.1	13.0	14.7	12.6	13.3	13.2	13.6
K4	---	---	---	---	14.1	13.8	11.8	13.4	12.3	12.4	12.6	13.4	13.0
Ky36-11	---	---	---	---	11.1	14.4	11.1	11.9	11.4	12.6	10.6	12.0	11.9
CI7	---	---	---	---	11.5	11.3	12.0	12.9	12.6	13.2	13.8	---	12.5

TABLE 4.--Analysis of variance of oil and protein contents of 7 corn inbreds grown at 8 locations in 2 years

Source of variation	Degrees of freedom	Oil content		Protein content	
		Mean square	F-value	Mean square	F-value
Season	1	8.3603	2.41	0.5294	1.39
Location	7	1.3748	.40	.1506	.39
Location X season	7	3.4678	**7.09	.3819	**4.85
Inbred line	6	33.0445	**24.00	9.9222	**35.83
Inbred X season	6	1.3766	2.81	.2769	3.52
Inbred X location	42	.6987	1.43	.0799	1.02
Inbred X location X season	42	.4901	---	.0787	---

** Exceeds 1-percent level of significance.